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DRAWINGS ATTACHED

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(54) METHOD AND APPARATUS FOR JOINING ENDS OF PIPE SECTIONS BY DRIVEN FORCE FIT AND JOINTS FORMED THEREBY

(71) I, WADSWORTH WALTON MOUNT, a citizen of the United States of America, of 154 Mountain Avenue, Warren, Plainfield, New Jersey, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method and apparatus for producing a pipe joint.

It has been proposed to join pipe sections of equal diameter and equal wall thickness by means of a tapered fit, i.e., by oppositely tapering the two ends which are to be joined. The two ends may then be simply forced together, or one may be heated and the other cooled before they are moved together to provide a shrink fit, as disclosed in U.S. Patent Specification No. 3,114,566.

An alternative method of connecting pipe sections of substantially the same diameter and wall thickness is to provide a peripheral ridge on one section and a mating groove on the other section, so that the ridge and groove snap together when one section is forced into the other, as disclosed for example in U.S. Patent Specification No. 3,217,400.

British Patent Specification No. 928,911 corresponds to the U.S. Patent Specification No. 3,217,400, except that it additionally describes a joint between two thermoplastic piped sections of "like internal and external diameter". In that joint, the inner pipe section is slightly compressed, apparently throughout the length of the joint.

British Patent Specification No. 435,700 discloses a force fit between overlapping pipe sections of different diameters. The dimensions are so selected that the inside diameter of the outer pipe section is "very slightly smaller" than the outer diameter of the inner pipe section.

In my Patent No. 1,153,150, there is claimed a method of coupling two metal pipe sections, each section having an unstressed internal diameter substantially less than the external diameter of the other section, which comprises flaring one end of one pipe section so that its internal diameter at the flared end is greater than the external diameter of an unflared end of the other pipe section, and forcing an unflared end of the other pipe section into said flared end until the ends of the sections are overlapping, so that only the tip of the unflared pipe is contracted slightly while the remainder of the overlapped portion of the inner pipe retains substantially its original inside diameter, and the overlapping portion of said one section expands substantially to accommodate said other pipe section, and the overlapped portions engage and hold one another tightly.

Said Patent also claims apparatus for joining two pipe sections of substantially equal size which comprises means for holding said pipe sections in axial alignment, means for circumferentially expanding an end of one of said pipe sections and means for axially forcing the adjacent end of said other pipe section into said expanded end of the first section.

Further, said Patent also claims a pipe coupling, comprising two cylindrical metal pipe sections, each of substantially constant wall thickness, each having an unstressed internal diameter substantially less than the unstressed external diameter of the other section, end portions of said pipe sections being telescoped, with the overlapping end portion of one section having its inside and outside diameters expanded substantially from their unstressed values so that said end portion is outside and concentric with the overlapped end portion of the other section, and the dimensions of the overlapped end portion remain substantially at their

unstressed values, said overlapping end portion being stressed circumferentially in tension, and said overlapped end portion being stressed circumferentially in compression, and said stresses being effective to hold said telescoped end portions in tight sealing relation.

The present invention is concerned with an improvement to ensure pipe sections are maintained in alignment while being driven into overlapping relationship.

According to one aspect of the present invention, there is provided a method of forming a driven force fit overlap joint between first and second metal pipe sections, said first section having unstressed internal dimensions smaller than the external dimensions of the second section, comprising the steps of:

(a) flaring on end of said first section to accommodate entry of the second section into the first section;

(b) positioning said sections in axial alignment with said flared end adjacent the second section;

(c) gripping said sections with pipe gripping means and moving said gripping means to drive at least one of said axially aligned sections toward the other to force said sections into overlapping contacting relationship for a distance longer than said flared end, thereby expanding said first section so that the overlapping contacting portions of said sections hold one another tightly; and

(d) engaging said sections with a guiding means separate from said gripping means and co-operating with each of said sections along a portion of its length so as to maintain said sections in axial alignment throughout the driving movement.

According to a second aspect of the invention, there is provided apparatus for forming an overlap joint between two metal pipe sections, the first of which has unstressed internal dimensions smaller than the external dimensions of the other and has a flared end at the locality at which initial engagement of said sections is to take place, said flared end being shorter than the overlap but of sufficient length to allow the said section to receive the end of the joint-forming length of the other section, said apparatus comprising:

(a) guiding means for each section and for engaging the respective sections to position them in axial alignment, with said flared end adjacent an end of the joint-forming length of the other section; and

(b) pipe gripping means separate from said guiding means for moving at least one of said axially aligned sections toward the other to bring said flared end and said end of the joint-forming length into contact and thereafter to force said sections into overlapping contacting relationship for a distance substantially greater than the length of said flared end, thereby substantially expanding said first section throughout said distance so that the overlapping contacting portions of said sections engage and hold one another tightly, the guiding means engaging each said section along a portion of its length so as to maintain said sections in axial alignment throughout the relative movement of the sections.

According to a third aspect of the invention, there is provided pipe joint forming apparatus, comprising:

(a) guide means for holding first and second pipe sections in axial alignment;

(b) driving means for exerting a force in the axial direction of the first pipe section;

(c) force transfer means attachable to said driving means for engaging a second pipe section, said force transfer means and said driving means being adapted to drive said second pipe section into the flared end of the first-mentioned pipe section until the pipes overlap by a substantial distance;

(d) said force transfer means being separate from said guide means and comprising two gripping means, respectivelly attachable to the two pipe sections to be joined near adjacent ends thereof;

(e) said driving means comprises fluid motor means for driving said two gripping means toward one another, including a piston attached to one gripping means, a cylinder attached to the other gripping means, and a piston rod connecting the piston to said one gripping means; and

(f) flaring tool means comprising a conical member removably connectable to said motor means in alignment with the end of said first pipe section; said fluid motor means being operable to force said conical member into said first pipe section to spread the open end thereof.

With the method and apparatus of the invention, as with the invention of Patent No. 1,153,150 the tip of the inner pipe section is compressed inwardly as the forcing of the pipe sections begins, and the slightly tapered tip thereby formed on the inner pipe section serves as a forming tool to spread the outer pipe section during the remainder of the relative travel of the two sections. Since the compressive strength of

the metals commonly used for pipes is greater than its tensile strength, the outer pipe section, being stressed in tension, deforms to accommodate the inner section while the latter is not deformed substantially except at its tip.

The inner pipe section is not contracted except at its tip, so that the inner diameter of the pipe line is not noticeably reduced. In some material, e.g., steel, the tip of the inner section is contracted by the forcing operation far enough so that it just clears the wall of the outer pipe. In that event, the spreading of the outer pipe is done by a rounded shoulder of the inner pipe, rather than a sharp edge at an end of the inner pipe, so that there is no abrupt change in the diameter of either pipe section, thereby facilitating the forming of the joint.

If the inwardly bent tip of the pipe section constitutes an objectionable restriction, it may be removed by grinding or cutting or by deforming the pipe sections outwardly at the restriction sufficiently to smooth the inner surface.

The product of the foregoing method and apparatus is a joint between a pair of metal pipe sections having substantially equal unstressed inside diameters and substantially equal unstressed outside diameters, connected by a driven force fit overlap joint between the ends of the sections. The joint is formed by substantial expansion of the outer section, but without substantial restriction of the inside diameter of the inner section. The joint so formed is fluid tight without the use of a bonding agent, although a bonding agent may be used if the joint is to be subjected to extremely high pressures.

In the accompanying drawings:—

Fig. 1 is a plan view, with certain parts shown in section, of pipe section joining apparatus constructed in accordance with the invention of Patent No. 1,153,150;

Fig. 2 is a sectional view of two pipe sections which are about to be joined;

Fig. 3 is similar to Fig. 2, but illustrates the completed pipe joint;

Fig. 4 is a view similar to Fig. 3, illustrating one method of removing the restriction in the interior of the pipe created by the pipe joint;

Fig. 4A is a cross-sectional view, similar to Fig. 4 showing a method of forming a pipe joint in accordance with the present invention;

Fig. 5 is a view similar to Fig. 4, illustrating an alternative method of removing the restriction;

Fig. 6 is a cross-sectional view along the lines 6-6 of Fig. 5;

Fig. 7 is an elevational view of a more complex form of apparatus in accordance with the present invention for forming a pipe joint;

Fig. 8 is a cross-sectional view taken on the line 8-8 of Fig. 7;

Fig. 9 is a cross-sectional view taken on the line 9-9 of Fig. 7;

Fig. 10 is a cross-sectional view taken on the line 10-10 of Fig. 7;

Fig. 11 is a cross-sectional view taken on the line 11-11 of Fig. 7; and

Fig. 12 is a cross-sectional view taken on the line 12-12 of Fig. 7.

Figures 1 to 3 illustrate, somewhat diagrammatically, a simple form of apparatus for joining pipe sections, and a simple method of joining pipe sections using that apparatus. This method and apparatus is described and claimed in my Patent No. 1,153,150 and no further claim thereto is made in the present Application.

In Fig. 1, a pipe section 1 is to be joined to another pipe section 2. The two pipe sections are conventional run-of-the-mill pieces of pipe. While they are nominally cylindrical, and are nominally of constant wall thickness, it is known and expected that such pipe sections are subject to considerable variation, both as to the circularity of their cross-section, their wall thickness, and the roughness of the edges at their ends. The method and apparatus is adapted to accept such pipe sections and form tight, leakproof joints between them, without the necessity of taking special precautions to assure either that the ends to be joined have circular cross-sections, that their wall thicknesses are uniform, or that their edges are smooth.

The apparatus for joining the pipe sections, as shown in Fig. 1, includes a pair of pipe gripping means generally indicated at 3 and 4 and a pair of fluid motors 8 and 9 connected to a common control device 7 which regulates the supply of motor fluid to those motors.

Each of the pipe gripping means 3 and 4 comprises an inner wedge means 5 and an outer wedge means 6. The inner wedge means 5 are built up from segmented wedge sections 5a. The inner surfaces of the wedge sections 5a may be toothed, as shown at 5b to facilitate their gripping of the pipe sections. The outer surface of each wedge section 5a is provided with a tapered surface 5c which cooperates with another tapered surface 6a on the inside of the outer wedge means 6. Each inner wedge member 5 encircles the pipe and is held in place by the outer wedge means 6, which may consist of two semi-annular parts, hinged together at one side, and fastened at the opposite side by suitable means, e.g., bolts.

The fluid motors 8 and 9 each comprise a cylinder 8a, 9a and a cooperating piston

8b, 9b. The cylinders 8 and 9 may be fastened by suitable means (not shown) to the right-hand outer wedge means 6. The pistons 8b, 9b are connected to piston rods 10 which extend through aligned apertures in the outer wedge means 6. The piston rods 10 are provided with a row of spaced diametrical holes 10a adapted to receive pins 11, which are shown, for example, at the side of the left-hand wedge means 6.

A flaring tool 12 comprises a disc 12a and a central section 12b, shown projecting to the right from the disc and shaped like the frustum of a cone.

The diameter of the disc 12a is large enough so that the flaring tool spans the two piston rods 10, and is provided with apertures 12c to receive those piston rods. The flaring tool must be aligned with the axis of the pipe section to be flared. Tilting of the flaring tool may be inhibited by using more than two points of driving contact.

While pipe sections of equal wall thickness have been shown, it may at times be desirable to join sections of unequal wall thickness. In particular, it is in many cases desirable to use an outer pipe section which is only thick enough to provide the necessary grip, while the inner pipe section may be made much thicker, as required.

When joining two pipe sections 1 and 2 with the apparatus of Fig. 1, the first step is to flare an end of one of the pipe sections, illustrated as the section 1. For that purpose, the inner wedge means 5 is mounted on the pipe section 1 at a convenient distance from one end thereof and the outer wedge means 6 is mounted outside the wedge means 5. The fluid motors 8 and 9 are then placed with the left-hand ends of their cylinders abutting the wedge section 6 and their piston rods 10 extending through the apertures 6b provided in the wedge section 6. The flaring tool 12 is then mounted over the piston rods in alignment with the open end of the pipe section 1, and pins 11 are inserted in a pair of selected holes 10a in the piston rods 10. The conical section 12b of the flaring tool is then driven into the end of the pipe section 1 by supplying fluid to the left-hand end of the cylinders 8a and 9a through the control device 7. The end of the pipe section 1 is thereby flared as illustrated at 1a in Fig. 2. It should be noted that this flare is made circular in cross-section by the conical configuration of the flaring tool portion 12b. Thus the flare contour is always circular in cross-section, regardless of the fact that the pipe section 1 may originally have been somewhat elliptical in cross-section or may have had uneven wall thickness or rough edges.

The flare 1a need only be enough so that its inner diameter at the end of the flare, is slightly greater than the outer diameter of the pipe section to be driven into the flare.

After the flare 1a is completed, the fluid motors 8 and 9 are reversed to back the flaring tool 12 away from the pipe section 1, and the flaring tool 12 is then removed from the piston rods 10.

Another inner wedge means 5 is then mounted on the pipe section 2, which is brought into alignment with the flared end of section 1. An outer wedge means 6 is mounted over the piston rods 10 and in engagement with the inner wedge means 5. Position pins 11 are fixed in the piston rods 10. The pipe section 2 is then moved to the position illustrated in Fig. 2, where its end is just entering the flared portion 1a of the pipe section 1. Additional power is then supplied to the fluid motors 8 and 9, forcing the end of the pipe section 2 into the pipe section 1. As this forcing operation begins, the end of the pipe section 2 is bent inwardly, being compressed by its contact with the pipe section 1, forming a bent-in nose portion 2a, as shown in Fig. 3. This bent-in nose substantially reinforces the end of the pipe against further bending. The bending in of the nose proceeds only far enough to make the compressive strength of the inner section 2 at that nose equal to the force needed to expand the section 1 outwardly. As the forcing proceeds, the portion of pipe section 1 adjacent its end is spread outwardly by the pipe section 2. The pipe section 2 is not substantially contracted, except at the extreme tip, as shown at 2a.

With certain materials, e.g., steel, the tip of the pipe section at 2a is contracted, during the initial phase of forcing the pipe sections together, by a sufficient amount so that its outer edge clears the inner diameter of the pipe section 1, as shown at 14. This facilitates further driving of the pipe section 2 into the pipe section 1, since the contact between the two sections takes place between smooth rounded shoulders on both sections rather than between a sharp edge of one section and a surface of the other. Furthermore, the space 14 facilitates the speading of an adhesive or sealant, when such is used.

With other materials, e.g., certain aluminum alloys, the tip of the pipe section 2 bends in over a longer distance and thus reduces its inner diameter by extrusion to a greater extent than the harder materials. The space 14, with such materials, is less pronounced than with steel. Nevertheless, the forcing operation may take place without damage to either pipe section or to the joint.

The forcing operation should continue until the end of the pipe section 2 is re-

ceived within the pipe section 1 for an axial distance substantially greater than the flare 1a. It has been found convenient to continue the forcing until the pipe sections overlap by approximately one diameter. However, the forcing operation can be continued much beyond that point. Friction between the overlapped parts rises steadily as the length of the overlap increases. When that friction equals the column strength of the pipe, then, if the operation is continued further, one or the other of the pipe sections will be deformed, usually by wrinkling at a point spaced from the joint. If the gripping means are immediately at the ends of the joint, the deformation will be in the overlapped parts.

While it is not necessary, in the simplest form of joint, to use any sealing material between the pipes, there is no reason why such sealing material cannot be used to provide further assurance when a completely tight, leakproof joint is required.

Tests on light wall, i.e., 0.125″, and heavy wall, i.e., 0.322″, steel pipes show that the force required, to overlap the pipes to make this force-fit joint, builds up steadily the longer the overlap.

For instance, a test on nominal 5″ steel pipe having a wall thickness of 0.258″ produced force vs. penetration figures as follows:

	Penetration	*Force*
To flare	Flare	82,500 lbs.
To overlap	1″	80,000
	2″	106,000
	3″	137,500
	4″	170,000
	5″	194,000
	6″	214,000
	7″	232,500
	7½″	248,000

Numerous tests have shown that the axial force required to cause the joint to separate is substantially equal to the maximum force used to form the joint when no adhesive is used. Higher values are obtainable with the use of adhesives.

It has been found that, with steel pipe joints, the original flare, as shown at 1a becomes contracted slightly as the joint is formed so that the flare becomes more nearly like that shown at 1b in Fig. 3, and may even close snugly down against the pipe section 2.

The overlap may be continued until a point is reached where the compressive strength of one of the pipe sections is less than the force required to increase the overlap. At that point, further attempts to increase the overlap will cause wrinkling or other failure of one of the pipe sections outside the overlapped joint.

The completed joint, as shown in Fig. 3. has an internal restriction to flow formed by the bent-in nose 2a. This restriction may be removed by performing one of the additional steps illustrated below in connection with Figs. 4 to 6. However, when turbulence in the fluid flow is desired to avoid build-up of deposits, as, for example, in some fuel pipe lines, the effect of the slight internal restrictions at the joints may be very useful.

Figures 4 to 6 illustrate methods by which the internal restriction formed by the nose 2a in Fig. 3 may be removed so that the pipe joint does not present any restriction to internal flow, or to the passage of pipe line cleaning tools. In Fig. 4, there is shown a grinding wheel 15 inserted through the pipe section 2 on the end of a motor driven shaft 16. The grinding wheel may be utilized to remove the excess material forming the bent-in nose 2a. When the material is completely removed, the joint presents no restriction to internal flow. Nevertheless, there has been no weakening of the joint by the removal of that material.

Instead of using a grinding tool, a metal cutting tool may be utilized to remove the excess material.

In Figs. 5 and 6, there is shown a method and apparatus by which the internal restriction may be removed without taking away any material. In these figures, there is inserted through the pipe section 2 a shaft 17 carrying on its end a rolling mechanism, including a pair of rollers 18 mounted between two parallelogram linkages 19, each driven by two diametrically opposed crank arms 20 which are fixed on the shaft 17. In each linkage 19, two fluid motors 21 are connected between the crank arms 20 and the rollers 18. The motors 21 and operable by remote control from outside the end of the pipe to force the rollers 18 against the interior of the pipe. When the rollers 18 are so forced against the pipe, and the shaft 17 is rotated, the bent-in nose is deformed outwardly against the pipe section 1. The operation is continued until the inside surface of the joint is smooth. The fluid for the motors 21 may flow through a passage provided in the shaft 17, and hence the operation of those motors may be externally controlled.

In each of the methods shown and/or described in connection with Figs. 4-6, which may also be applied to the later described methods of forming a pipe joint in accordance with the present invention, the tip of the inner pipe section and the adjacent portion of the outer pipe section are of complementary form, so that the inner surface of the joint is substantially smooth.

Figure 4A illustrates a method of forming a pipe joint in accordance with the present invention. Here, the restriction of flow

due to an inturned nose on the end of the inner pipe is minimized by forming the joint around a mandrel 22. By selecting the clearance between the inside of the pipe and the outside of the mandrel, the inturned nose can be made as small as desired. The mandrel takes some of the compressive load from the inturned nose. The mandrel should not be selected so big that it is difficult to withdraw.

The mandrel 22 may be of conventional construction, and may be withdrawn by conventional apparatus.

The mandrel 22 also guides the two pipe sections and keeps them in axial alignment during the joint forming operation. It may also at least partially support one or both of the pipe sections during that operation.

The apparatus illustrated in Figures 7 to 12 is adapted to carry out a method similar to that performed by the apparatus of Fig. 1, but the apparatus of these figures is more elaborate, to provide the additional guide means of the present invention. This apparatus is supported on a pair of parallel I-beams 25. The ends of the I-beams 25 have their lower flanges turned up and welded at their ends to the upper flanges, as shown at 25a in Fig. 7, to facilitate a sliding movement of the beams 25 along the ground or other underlying support. Affixed to each pair of adjacent ends of the I-beams 25 and spanning the space between them is a guide 26, best shown in Fig. 8, adapted to receive and encircle the pipe sections 1 and 2 with a loose slip fit. Each guide 26 comprises a base 27 welded to the ends of the I-beams 25 and having a saddle 27a formed in its upper surface for receiving a pipe section, such as the section 2. The guide 26 also includes a cap 28 connected to the base 27 by a pivot pin 29. Cap 28 may be fastened to the base 27 by means of a bolt 30.

A wedge mechanism 31, best seen in Fig. 9, is fixed on the I-beams 25 at a point spaced from the left-hand guide 26. The wedge mechanism 31 includes a base 32 welded to the I-beams and a cap 33 connected to the base 32 by a pivot pin 34 and a bolt 35. The base 32 and the cap 33 comprise the outer one of a pair of cooperating wedge elements, corresponding to the wedge element 6 of Fig. 1.

The wedge mechanism 31 also comprises inner segmented wedge section 36 held in place in the conical aperture between the base 32 and the cap 33. The inner wedge section 36 may be provided with pipe gripping teeth, such as those shown at 5b in Fig. 1. The base 32 is connected through a pivot generally indicated at 37 to the cylinder 38 of a fluid motor. Similarly, the cap 33 is connected through a pivot 39 to the cylinder 40 of another fluid motor. Piston rods 41 and 42 of the fluid motors extend from the opposite end of the cylinders 38 and 40, respectively, and are connected respectively to the base 43 and the cap 44 of another wedge mechanism generally indicated at 45. The wedge mechanism 45 is generally similar to the wedge mechanism 31, except that it is free to slide longitudinally of the I-beams 25, being held in axial alignment with the wedge mechanism 31, by beams 46 of L-shaped cross-section attached to the outer sides of the base 43 and having their flanges extending under the upper flanges of the I-beams 25, as shown in Fig. 11. The beams 46 are held in place by bolts 47. The beams 25 and 46 and the wedge mechanisms 31 and 45 must be sufficiently strong to hold those wedge mechanisms in axial alignment.

As in the case of the wedge mechanism 31, the wedge mechanism 45 includes inner segmented wedge sections 48, which may be toothed to facilitate gripping of the pipe section 1.

A flaring tool 53 is illustrated in Figs. 7 and 10 and includes a disc portion 53a and a central portion 53b in the shape of the frustum of a cone. Disc portion 53a is cut away, as shown at 53c, to allow the flaring tool to be moved in laterally between the wedge mechanisms 31 and 45, and to rest on and be centered by the piston rods 41 and 42. A screw eye 54 is attached to the upper surface of the flaring tool 53 to facilitate its movement. After the flaring tool 53 is moved into position on the piston rods 41 and 52, its flaring section 53b may be driven into the end of the pipe section 1 by operating the fluid motors 38 and 40. The motors draw the wedge mechanism 45 and its engaged pipe section 1 toward the flaring tool until they touch. Thereafter the flaring tool is forced by the pipe section 1 along the piston rods 41 and 42 until its disc portion 53a engages the ends of the cylinders 38 and 40. Thereafter, the continued operation of the motors is effective to flare the end of the pipe section 1.

Between each of the wedge mechanisms 31 and 45 and the nearest end of the base 25, there is provided a yoke 50, best seen in Fig. 12, having a lower arm welded across the two I-beams 25 and an upper arm extending substantially to the center line of the apparatus. The two yokes 50 are connected at their upper ends by another I-beam 51, which has welded on its upper surface a loop 52 to facilitate lifting of the entire apparatus by means of a crane, or the like. In some cases, it may be desirable to fasten the yokes 50 removably to the I-beams 25, to facilitate transportation of the apparatus. The I-beam 51 is useful for hanging tools, e.g., a block-and-tackle,

to facilitate lifting and handling of parts of the apparatus and pipe sections.

The operation of forming a pipe joint with the apparatus of Figs. 7 to 12 is substantially the same as the operation described in connection with Figs. 1 to 3. That operation may be followed by the steps for removing internal restrictions described in connection with Figs. 4 to 6.

The description of Figs. 1 to 3 above, assumes that the pipe section 1 is at the end of a pipe line already laid in the ground or along the surface of the ground and that the pipe section 2 is forced into it to form the joint. In the apparatus of Figs. 7 to 12, it is assumed that the pipe section 2 is stationary and that the pipe section 1 is to be forced over the end of the pipe section 2. Thus, it should be clear that it does not matter with respect to the present invention whether the flared pipe section is the stationary part of the joint or whether the unflared section is the stationary part. In fact, it is not necessary that either part be stationary, but it should be clear that the invention may be used in connection with a field operation, e.g., the laying of a pipe line, where one of the sections to be joined is stationary.

The bent in nose 2a is best formed as described above, i.e., by flaring the outer section at 1a, and then driving the tip of section 2a into the flared outer section, so that the nose is self-adaptively formed. In other words, the nose bends in as it engages the flare, and as it bends, its resistance to further bending increases. The inward bending of the nose continues until it is just strong enough to spread the outer section as the driving action continues. The nose 2a varies in configuration automatically depending upon the conditions encountered, such as: the respective wall thicknesses of the sections 1 and 2; the various forces acting, some axially and some circumferentially of the pipe sections; and the stresses in the two pipe sections.

In any of the embodiments of the invention using overlapping pipe sections, it is generally preferred to use pipe sections of substantially equal wall thickness and substantially equal diameters. However, the inner pipe section can have a relatively thick wall, and the outer pipe section may have a relatively light and stretchable wall.

In any of the embodiments, it is presently preferred to use a flare angle of about 15°.

In any of the modifications of the invention, the surfaces of the overlapped members need not be smooth, but will nevertheless conform tightly in the overlapped joint. For example, if one of the members is grooved, the material of the other member will extrude to fill the grooves and make the joint tight. The opposed contracting force of the outer member and the expanding force of the inner member are sufficiently great to produce the described extrusion.

WHAT I CLAIM IS:

1. A method of forming a driven force fit overlap joint between first and second metal pipe sections, said first section having unstressed internal dimensions smaller than the external dimensions of the second section, comprising the steps of:

(a) flaring one end of said first section to accommodate entry of the second section into the first section;

(b) positioning said sections in axial alignment with said flared end adjacent the second section;

(c) gripping said sections with pipe gripping means and moving said pipe gripping means to drive at least one of said axially aligned sections toward the other to force said sections into overlapping contacting relationship for a distance longer than said flared end, thereby expanding said first section so that the overlapping contacting portions of said sections hold one another tightly; and

(d) engaging said sections with a guiding means separate from said gripping means and cooperating with each of said sections along a portion of its length so as to maintain said sections in axial alignment throughout the driving movement.

2. A method as in claim 1, wherein said guiding means is constituted by a mandrel positioned to extend through the joint within said sections.

3. A method as claimed in claim 1 or claim 2, wherein the driving step is effective to form a bent-in nose constituting an internal restriction on the end of the inner pipe section, the method also including the step of removing the internal restriction of the coupled pipe sections at the bent-in nose by a metal removing tool inserted through an open end of the coupled pipe sections.

4. A method as claimed in claim 1 or claim 2, wherein the driving step is effective to form a bent-in nose constituting an internal restriction on the end of the inner pipe section, the method also including the step of removing the internal restriction of the coupled pipe sections at the bent-in nose by inserting a rolling tool through an open end of the coupled pipe sections to force the material of the nose outwardly to match the inside diameter of the other parts of the coupled pipe sections.

5. Apparatus for forming an overlap joint between two metal pipe sections, the first of which has unstressed internal dimensions smaller than the external dimensions of the other and has a flared end at the

locality of which initial engagement of said sections is to take place, said flared end being shorter than the overlap but of sufficient length to allow the said section to receive the end of the joint-forming length of the other section, said apparatus comprising:

(a) guiding means for each section and for engaging the respective sections to position them in axial alignment with said flared end adjacent an end of the joint-forming length of the other section; and

(b) pipe gripping means separate from said guiding means for moving at least one of said axially aligned sections toward the other to bring said flared end and said end of the joint-forming length into contact and thereafter to force said sections into overlapping contacting relationship for a distance substantially greater than the length of said flared end, thereby substantially expanding said first section throughout said distance so that the overlapping contacting portions of said sections engage and hold one another tightly, the guiding means engaging each said section along a portion of its length so as to maintain said sections in axial alignment throughout the relative movement of the sections.

6. Apparatus as in claim 5, in which said guiding means is a mandrel extending through both pipe sections.

7. Apparatus as in claim 5, in which:

(a) said guiding means is external to said sections; and

(b) said guiding means includes a pair of means mounted on a rigid structure at spaced localities for encircling the respective pipe sections.

8. Pipe joint-forming apparatus, comprising:

(a) guide means for holding first and second pipe sections in axial alignment;

(b) driving means for exerting a force in the axial direction of the first pipe section;

(c) force transfer means attachable to said driving means for engaging a second pipe section, said force transfer means and said driving means being adapted to drive said second pipe section into a flared end of the first pipe section until the pipe sections overlap by a substantial distance;

(d) said force transfer means being separate fro msiad guide means and comprising two gripping means, respectively attachable to the two pipe sections to be joined near adjacent ends thereof;

(e) said driving means comprises fluid motor means for driving said two gripping means toward one another, including a piston attached to one gripping means, a cylinder attached to the other gripping means, and a piston rod connecting the piston to said one gripping means; and

(f) flaring tool means comprising a conical member removably connectable to said motor means in alignment with the end of said first pipe section, said fluid motor means being operable to force said conical member into said first pipe section to spread the open end thereof.

9. Apparatus as in claim 8, in which the guide means includes a rigid structure extending longitudinally of said sections beyond the locality of the overlapping portions thereof in both directions, said structure having guide surfaces extending longitudinally of the sections and closely engaging said sections.

10. Apparatus as in claim 8, including:

(a) a support for said apparatus;

(b) means fixedly connecting said other gripping means to said support;

(c) means movably connecting the one gripping means to said support;

(d) said one gripping means being movable along said support by said driving means.

11. Apparatus as in claim 10, including means directing the motion of the one gripping means along the support, so that both gripping means are axially aligned.

12. Apparatus as in claim 8, including:

(a) a support adapted to extend longitudinally along the pipe sections to be joined;

(b) the two gripping means being located at spaced localities along said support;

(c) said guide means comprises a pair of guide means at the ends of said support, said guide means being aligned with the two gripping means and effective to guide the pipe sections engaged by the gripping means.

13. Apparatus as in claim 8, including:

(a) a support for said gripping means and said motor means;

(b) a pair of horizontally spaced vertically extending yokes, each attached at one end to said support, and having its opposite end spaced above said support;

(c) a beam connecting said other ends of said yokes;

(d) means on the beam adapted for engagement by a hoist to lift the apparatus.

14. A method of forming a driven force fit overlap joint between first and second pipe sections as claimed in any one of

claims 1-4, substantially as herein described with reference to Figs. 4 to 12 of the accompanying drawings.

15. Apparatus for forming an overlap joint between two pipe sections as claimed in any one of claims 5-13, substantially as herein described with reference to Figs. 4 to 12 of the accompanying drawings.

16. A pipe joint formed by the method of any one of claims 1-4 or claim 14.

17. A pipe joint formed by the apparatus of any one of claims 5-13 or claim 15.

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Sheet 1

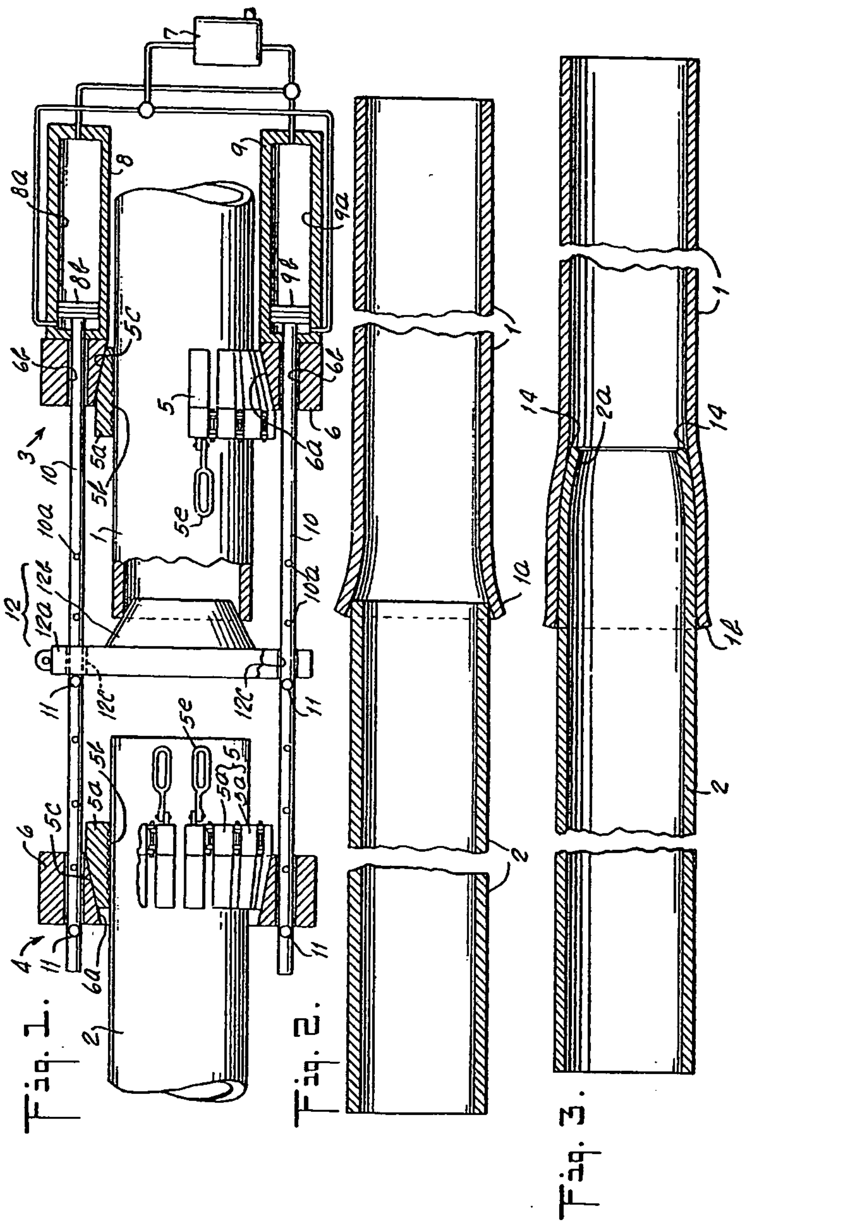


Fig. 4.

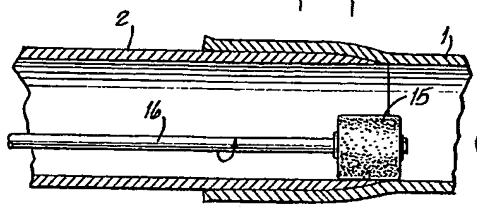


Fig. 4A.

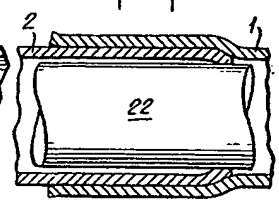


Fig. 5.

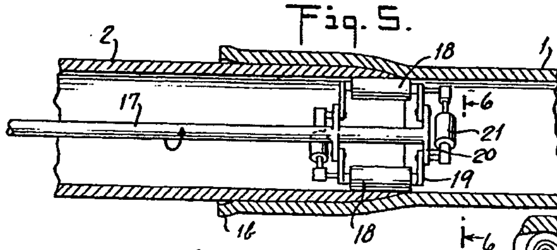


Fig. 6.

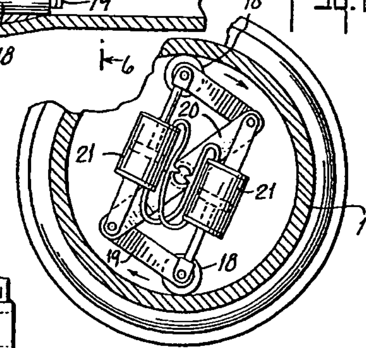


Fig. 8.

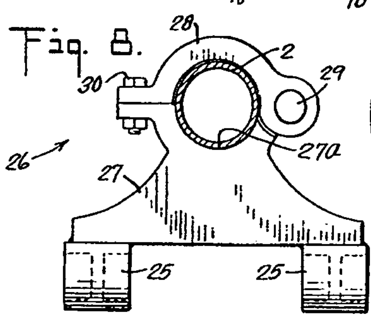


Fig. 9.

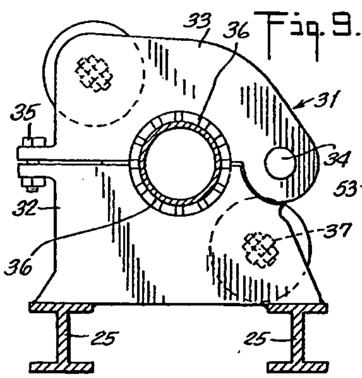
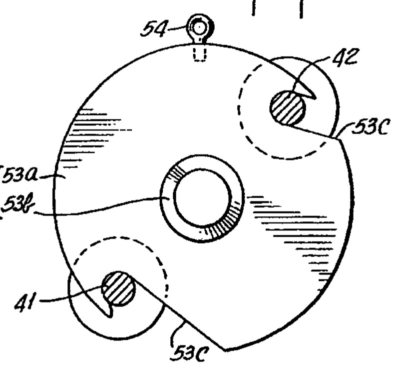


Fig. 10.



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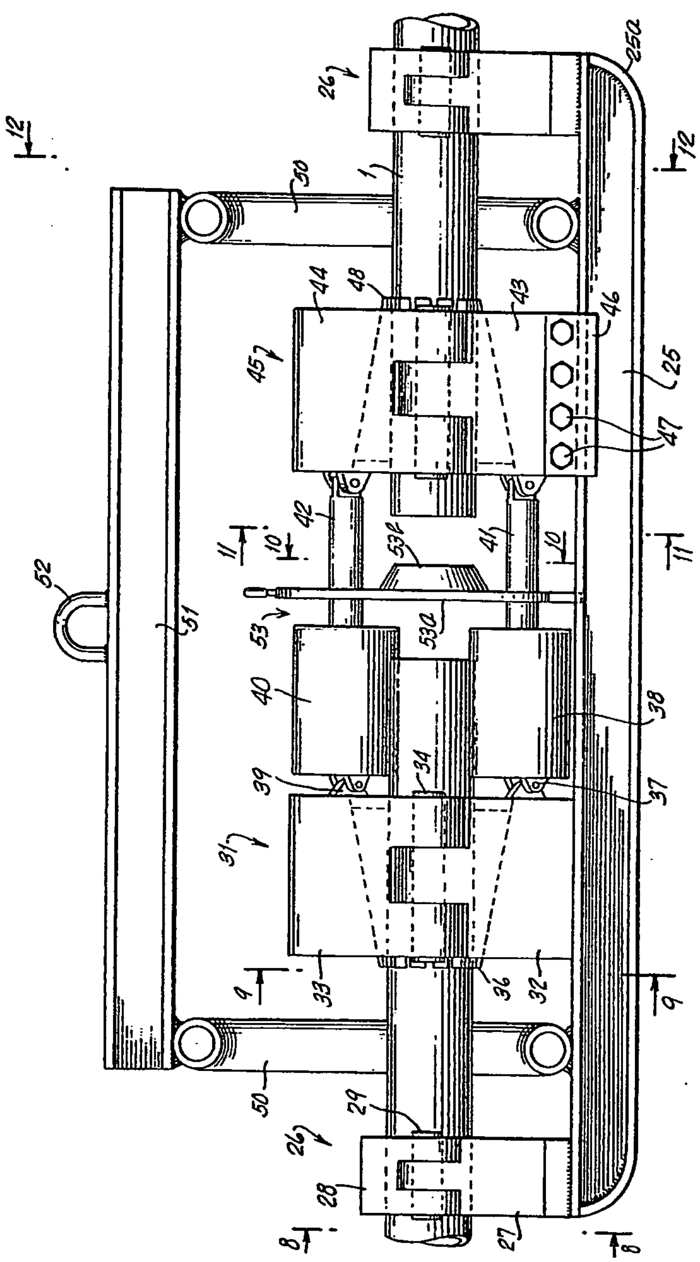

Fig. 7.

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Sheet 4

Fig.11.

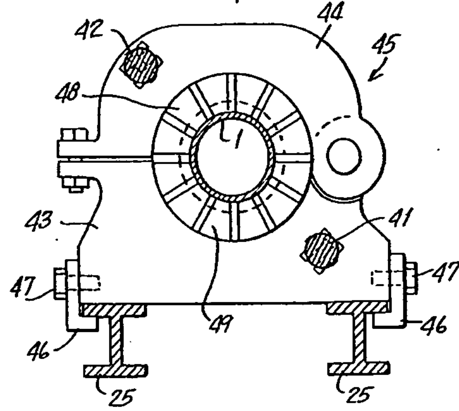

Fig.12.